

1 **RATCHET WHEEL WITH ASYMMETRIC ARCUATE CONCAVE TEETH OR**  
2 **NON-ARCUATE CONCAVE TEETH AND RATCHETING TOOLS WITH SUCH**  
3 **RATCHET WHEEL**

4 **Background of the Invention**

5 **1. Field of the Invention**

6 The present invention relates to a ratchet wheel with asymmetric arcuate concave teeth  
7 or non-arcuate concave teeth. The present invention also relates to a ratcheting tool, e.g., a ring  
8 spanner having a box end in which the ratchet wheel is mounted. The ratchet wheel with  
9 asymmetric arcuate concave teeth provides improved structural strength and improved torque.  
10 The ratchet wheel with non-arcuate concave teeth is easy to form and thus reduces the  
11 production cost.

12 **2. Description of the Related Art**

13 A wide variety of spanners and wrenches have heretofore been provided. Ring spanners  
14 are the best choice for driving fasteners (e.g., nuts, bolt heads, etc) in a limited space that is  
15 uneasy to access and difficult to operate all kinds of ratcheting tools. Nevertheless,  
16 conventional ring spanners have low driving torque. Ratchet type ring spanners have been  
17 proposed to solve this problem. A ratchet wheel is mounted in the box end of a ring spanner  
18 for driving fasteners at high torque. It is, however, found that, the structural strength of the  
19 ratchet wheel is weak, as an outer periphery of the ratchet wheel is processed to form a  
20 plurality of arcuate teeth with a considerable depth.

21 Figs. 11 through 13 of the drawings illustrate a conventional ratchet wheel 1 mounted in  
22 a box end (not shown) of a ring spanner (not shown) and having an inner periphery 4 for  
23 driving a fastener (not shown) and an outer periphery having a plurality of arcuate concave  
24 teeth 3. Referring to Fig. 12, each arcuate concave tooth 3 is formed by means of feeding a  
25 cutter 2 along a direction transverse to a radial direction (see line OR). The resultant concave  
26 tooth 3 has a depth "d" and two sides that intersect at point "R". The line OR divides the angle  
27  $\alpha$  defined by the two sides of the arcuate concave tooth 3 into two equal portions (usually

45° for each portion). As illustrated in Fig. 12, each arcuate concave tooth 3 is machined to have a considerable depth "d" that adversely affects the structural strength of the ratchet wheel 1, as the remaining wall thickness "t" of the ratchet wheel 1 is relatively small. As a result, the driving torque provided by the ratchet wheel for driving the fastener is limited.

Figs. 14 through 16 of the drawings illustrate a conventional ratchet wheel 5 mounted in a box end 9a (Fig. 17) of a ring spanner 9 (Fig. 17) and having an inner periphery 8 for driving a fastener (not shown) and an outer periphery having a plurality of arcuate concave teeth 6. Referring to Fig. 15, each arcuate concave tooth 6 is formed by means of feeding a cutter 7 along a radial direction. The resultant arcuate concave tooth 6 has a depth "d" and two sides that intersect at point "R". The line OR divides the angle  $\beta$  defined by the two sides of the concave tooth 6 into two equal portions (usually 45° for each portion). As illustrated in Fig. 15, each arcuate concave tooth 6 is machined to have a considerable depth "d" that adversely affects the structural strength of the ratchet wheel, as the remaining wall thickness "t" of the ratchet wheel 5 is relatively small. As a result, the driving torque provided by the ratchet wheel for driving the fastener is limited. Such structure has been disclosed in U.S. Patent No. 5,533,427 to Chow issued on Jul. 9, 1996, which is incorporated herein for reference. A further drawback of this conventional ratchet wheel is the low production rate for forming the arcuate concave teeth by cutting.

The present invention is intended to provide an improved ratchet wheel that mitigates and/or obviates the above problems.

### Summary of the Invention

It is a primary object of the present invention to provide an improved ratchet wheel has asymmetric arcuate concave teeth for providing improved structural strength and improved torque.

It is another object of the present invention to provide an improved ratchet wheel that has non-arcuate concave teeth to allow higher production rate, as the non-arcuate concave teeth can be formed by means of roll squeezing method, investment casting, or molding. The

1 non-arcuate concave teeth may be symmetric or asymmetric. The ratchet wheel with non-  
2 arcuate concave teeth may bear higher torque during ratcheting (i.e., tightening or loosening a  
3 fastener).

4 The present invention also provides a ratcheting tool, e.g., a spanner, equipped with a  
5 ratchet wheel in accordance with the present invention. In an embodiment of the invention, the  
6 spanner has a box end for receiving a ratcheting wheel with asymmetric arcuate concave teeth.  
7 In another embodiment of the invention, the spanner has a box end for receiving a ratcheting  
8 wheel with non-arcuate asymmetric concave teeth. In a further embodiment of the invention,  
9 the spanner has a box end for receiving a ratcheting wheel with non-arcuate symmetric  
10 concave teeth.

11 Other objects, advantages, and novel features of the invention will become more  
12 apparent from the following detailed description when taken in conjunction with the  
13 accompanying drawings.

#### 14 **Brief Description of the Drawings**

15 Fig. 1 is a perspective view of a ratchet wheel with asymmetric arcuate concave teeth in  
16 accordance with the present invention;

17 Fig. 2 is a side view of the ratchet wheel in accordance with the present invention;

18 Fig. 3 is a top view of the ratchet wheel in accordance with the present invention,  
19 illustrating formation of asymmetric arcuate concave teeth in an outer periphery of the ratchet  
20 wheel;

21 Fig. 4 is a top view of a box end of a ring spanner equipped with the ratchet wheel in  
22 accordance with the present invention;

23 Fig. 5 is a sectional view taken along line 5-5 in Fig. 4;

24 Fig. 6 is a top view, in an enlarged scale, of the ratchet wheel in accordance with the  
25 present invention, wherein position of symmetric concave teeth formed according to prior art  
26 is illustrated to show difference therebetween;

1 Fig. 7a is a perspective view of a pawl for cooperating with the asymmetric arcuate  
2 concave teeth of the ratchet wheel in accordance with the present invention;

3 Fig. 7b is a top view of the pawl in Fig. 7a;

4 Fig. 7c is a side view of the pawl in Fig. 7a;

5 Fig. 8a is a perspective view of a conventional pawl for cooperating with the arcuate  
6 concave teeth of the ratchet wheel in Fig. 14;

7 Fig. 8b is a top view of the pawl in Fig. 8a;

8 Fig. 8c is a side view of the pawl in Fig. 8a;

9 Fig. 9 is an enlarged fragmentary view illustrating operation of the pawl and the  
10 asymmetric arcuate concave teeth of the ratchet wheel in accordance with the present  
11 invention;

12 Fig. 10 is a schematic force diagram of the asymmetric arcuate concave tooth of the  
13 ratchet wheel in accordance with the present invention;

14 Fig. 11 is a perspective view of a ratchet wheel according to prior art;

15 Fig. 12 is a top view of the ratchet wheel in Fig. 11;

16 Fig. 13 is a side view of the ratchet wheel in Fig. 11;

17 Fig. 14 is a perspective view of another ratchet wheel according to prior art;

18 Fig. 15 is a top view of the ratchet wheel in Fig. 14;

19 Fig. 16 is a side view of the ratchet wheel in Fig. 14;

20 Fig. 17 is a top view of a box end of a ring spanner equipped with the ratchet wheel in  
21 Fig. 14;

22 Fig. 18 is an enlarged fragmentary view illustrating operation of the conventional pawl  
23 and the symmetric arcuate concave teeth of the conventional ratchet wheel in the ring spanner  
24 Fig. 17;

25 Fig. 19 is a schematic force diagram of the ratchet wheel in Fig. 14;

26 Fig. 20 is a sectional view taken along line 20-20 in Fig. 17;

Fig. 21 is a perspective view of a ratchet wheel with non-arcuate concave teeth in accordance with the present invention;

Fig. 22 is a side view of the ratchet wheel in Fig. 21;

Fig. 23 is a top view of a box end of a ring spanner equipped with the ratchet wheel in Fig 21;

Fig. 24 is a sectional view taken along line 24-24 in Fig. 23;

Fig. 25 is a top view of the ratchet wheel in Fig. 21, wherein position of symmetric concave teeth formed according to prior art is illustrated to show difference therebetween;

Fig. 26a is a perspective view of a pawl for cooperating with the non-arcuate concave teeth of the ratchet wheel in Fig. 23;

Fig. 26b is a top view of the pawl in Fig. 26a; and

Fig. 26c is a side view of the pawl in Fig. 26a.

#### **Detailed Description of the Preferred Embodiments**

Referring to Figs. 1 through 9 and initially to Figs. 1 through 3, a ratchet wheel 20 in accordance with the present invention generally includes an inner periphery 24 for driving a fastener (not shown) and an outer periphery having a plurality of arcuate concave teeth 22. Referring to Fig. 3, each arcuate concave tooth 22 is formed by means of feeding a cutter 26 along a direction transverse to a radial direction (see line OR). The resultant concave tooth 22 has a depth "d<sub>1</sub>" and two sides RA and RB that intersect at point "R". The line OR divides the angle  $\theta$  defined by the two sides RA and RB of the concave tooth 22 into two unequal portions (e.g., 30° and 60°, 40° and 50°, etc). Namely, every tooth 22 thus formed is "asymmetric", or the two sides for each teeth 22 is not equal, which is the most important feature of this embodiment of the present invention. As illustrated in Fig. 3, each concave tooth 22 is machined to have a depth "d<sub>1</sub>" that will not adversely affect the structural strength of the ratchet wheel, as the remaining wall thickness "t<sub>1</sub>" of the ratchet wheel 20 is still relatively large. As a result, the ratchet wheel 20 may bear a relatively large driving torque for driving the fastener.

1 Difference in the depth of the tooth 22 of the ratchet wheel 20 of the present invention  
2 and the depth of the tooth 6 of conventional ratchet wheel 5 (Fig. 14) is illustrated in Fig. 6.  
3 Namely, the remaining wall thickness " $t_1$ " of the ratchet wheel 20 of the present invention is  
4 greater than the remaining wall thickness " $t$ " of conventional ratchet wheel 5 that has the same  
5 size as the ratchet wheel 20. Referring to Figs. 4 and 17, the narrowest wall thickness ( $t_1 =$   
6 1.01 mm in Fig. 4 for a ratchet wheel having an outer diameter of 25.76 mm) of the ratchet  
7 wheel 20 of the present invention is almost twice as the narrowest wall thickness ( $t = 0.51$  mm  
8 in Fig. 17 for a ratchet wheel having an outer diameter of 25.76 mm) of conventional ratchet  
9 wheel 5. Thus, the structural strength and the driving torque of the ratchet wheel of the present  
10 invention are both improved.

11 Referring to Fig. 4, the ratchet wheel 20 in accordance with the present invention is  
12 rotatably mounted in a box end 38 of a ring spanner 40. A web area 39 between the box end  
13 38 and a handle 42 of the ring spanner 40 includes a compartment 36 for receiving a pawl 30.  
14 Figs. 7a through 7c illustrate the pawl 30. The pawl 30 includes a plurality of teeth 31 that are  
15 formed complimentary to the curvatures of the asymmetric arcuate concave teeth 22. An end  
16 33 of the pawl 30 is attached to an end of an elastic member 32 the other end of which is  
17 received in a cavity 34 defined in a wall 36a defining the compartment 36, best shown in Fig.  
18 4. Fig. 17 illustrates a conventional arrangement of a ratchet type ring spanner 9 that has a box  
19 end 9a for rotatably receiving the ratchet wheel 5. A web area (not labeled) of the ring spanner  
20 9 includes a compartment 10 for receiving a pawl 11. Figs. 8a through 8c illustrate the pawl 11.  
21 The pawl 11 includes a plurality of teeth 11a that are formed complimentary to the curvatures  
22 of the symmetric arcuate concave teeth 6. An end (not labeled) of the pawl 11 is attached to an  
23 end of an elastic member 12 the other end of which is received in a cavity 10a defined in a  
24 wall 10b defining the compartment 10, best shown in Fig. 17. Figs. 8a, 8b, 8c, and 17 are  
25 illustrated for comparison purpose. In addition, difference in the wall thickness of the ratchet  
26 wheel 20 of the present invention and the wall thickness of conventional ratchet wheel 5 can  
27 also be clearly seen in Fig. 6 and by means of comparing Fig. 5 with Fig. 20.

1 In use of the ring spanner equipped with the ratchet wheel 20 in accordance with the  
2 present invention, referring to Fig. 9, the angle  $\delta$  between a force N normal to the operative  
3 side P and the tangent T to the intersection I between the pawl 30 and the wall 36a defining  
4 the compartment 36 is smaller than that in the prior art ratchet wheel (see Fig. 18). As a result,  
5 the pawl 30 in Fig. 9 is reliably pushed toward the wall 36a defining the compartment 36 and  
6 thus provides a reliable engagement between the teeth 22 of the ratchet wheel 20 and the teeth  
7 31 of the pawl 30. If the angle  $\delta$  reaches  $90^\circ$ , the pawl moves toward the central area of the  
8 ratchet wheel and thus results in an undesired "sliding" effect, as there is no horizontal force  
9 imparted to move the pawl toward the wall 36a of the compartment 36. Thus, the ratchet  
10 wheel 20 and the pawl 30 in accordance with the present invention provides an engagement  
11 reliable than that between the conventional ratchet wheel 5 and the pawl 11 and thus less  
12 likely to "slide". The spanner with the ratchet wheel/pawl combination in accordance with the  
13 present invention can be used in a relatively small space and can be operated in a convenient  
14 manner. More specifically, the spanner is allowed to rotate in a reverse direction without  
15 disengaging the box end from the fastener when the spanner is stopped by an obstacle during  
16 ratcheting. And the spanner is then ready for next ratcheting movement. This is very  
17 convenient and timesaving.

18 Referring to Figs. 9 and 10, when the operative side P of the tooth 22 of the ratchet  
19 wheel 20 in accordance with the present invention is subjected to a force F during ratcheting,  
20 the area filled by the pawl 30 for bearing such force F is  $2/1.732 h^2$ . Referring to Fig. 19, for a  
21 conventional ratchet wheel 5, when either operative side P of the tooth 6 of the ratchet wheel 5  
22 is subjected to a force F, the area filled by the pawl 11 for bearing such force F is  $h^2$  which is  
23 smaller than that provided by the ratchet wheel/pawl combination in accordance with the  
24 present invention. Namely, the ratchet wheel 20 with asymmetric arcuate concave teeth 22  
25 provides a higher torque for ratcheting (i.e., tightening or loosening a fastener such as a nut or  
26 bolt head).

1 Referring to Figs. 21 and 22, in a second embodiment of the ratchet wheel in accordance  
2 with the present invention, the ratchet wheel (now designated by 50) includes an inner  
3 periphery 54 for driving a fastener (not shown) and an outer periphery having a plurality of  
4 non-arcuate concave teeth 52. The non-arcuate concave teeth 52 is formed by means of roll  
5 squeezing method, investment casting, or molding, which is quicker than formation by cutter.  
6 Each non-arcuate concave tooth 52 may be trapezoidal, triangular, or any other shape that  
7 results from formation other than cutting. The production cost for the ratchet wheel 50 with  
8 non-arcuate concave teeth 52 in accordance with the present invention is largely reduced, as  
9 the production time for the non-arcuate concave teeth 52 is relatively short. In addition, the  
10 non-arcuate concave teeth 52 may be symmetric or asymmetric. When the ratchet wheel 50  
11 has non-arcuate symmetric concave teeth 52, the resultant structure provides a driving torque  
12 approximately the same as that provided by the conventional ratchet wheel 5 with symmetric  
13 arcuate concave teeth 6. When the ratchet wheel 50 has non-arcuate asymmetric concave teeth  
14 52 configured similar to teeth 22, the resultant structure provides a higher driving torque than  
15 that provided by the conventional ratchet wheel 5 with symmetric arcuate concave teeth 6.

16 Referring to Fig. 23, the ratchet wheel 50 in accordance with the present invention may  
17 be rotatably mounted in a box end 38 of a ring spanner 40. A web area 39 of the ring spanner  
18 40 includes a compartment 36 for receiving a pawl 60. Figs. 26a through 26c illustrate the  
19 pawl 60. The pawl 60 includes a plurality of teeth 61 that are formed complimentary to the  
20 curvatures of the non-arcuate concave teeth 52. An end 62 of the pawl 60 is attached to an end  
21 of an elastic member 32 the other end of which is received in a cavity 34 defined in a wall 36a  
22 defining the compartment 36, best shown in Fig. 23. A detail comparison between the  
23 conventional pawl 11 illustrated in Figs. 8a through 8c, the pawl 30 of the first embodiment of  
24 the present invention illustrated in Figs. 7a through 7c, and the pawl 60 of this embodiment  
25 illustrated in Figs. 26a through 26c would be appreciated. In addition, difference in the wall  
26 thickness of the ratchet wheel 50 of the present invention and the wall thickness of



1 conventional ratchet wheel 5 can also be clearly seen in Fig. 25 and by means of comparing  
2 Fig. 24 with Fig. 20.

3 According to the above description, it is appreciated that the ratchet wheel with  
4 asymmetric arcuate concave teeth in accordance with the present invention provides a higher  
5 torque for operation and has improved structural strength as having a thicker wall in the  
6 ratchet wheel. The engagement between the ratchet wheel with asymmetric arcuate concave  
7 teeth and the pawl with asymmetric arcuate concave teeth is more reliable. The ratchet wheel  
8 with non-arcuate concave teeth in accordance with the present invention reduces the  
9 production cost for the ratchet wheel. The ratchet wheel with non-arcuate concave teeth also  
10 provides a higher torque for operation when the non-arcuate concave teeth is asymmetric. A  
11 spanner with the ratchet wheel/pawl combination in accordance with the present invention can  
12 be used in a relatively small space. Nevertheless, the ratchet wheel/pawl combination in  
13 accordance with the present invention is not limited to be used in the box end of a ring spanner.  
14 Namely, the ratchet wheel/pawl combination may be used in other ratcheting tools such as  
15 ratchet wrenches.

16 Although the invention has been explained in relation to its preferred embodiment, it is  
17 to be understood that many other possible modifications and variations can be made without  
18 departing from the spirit and scope of the invention as hereinafter claimed.